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Evaluation of multiple soil moisture products using in-situ observations over China

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Soil moisture (SM), a vital variable in the climate system, is applied in many fields. But the existing SM data sets from different sources have great uncertainty, hence need comprehensive verification. In this study, we collected and evaluated ten latest commonly used SM products over China, including four reanalysis data (ERA-Interim, ERA5, NCEP R2 and CFSR/CFSV2), three land surface model products (GLDAS 2.1 Noah, CLSM and VIC) and three remote sensing products (ESA CCI ACTIVE, COMBINED and PASSIVE). These products in their overlap period (2000-2018) were inter-compared in spatial and temporal variation. In addition, their accuracy was verified by a large quantity of in-situ observations. The results show that the ten SM products have roughly similar spatial patterns and small inter-annual differences, but there are still some deviations varying in regions and products. ERA5 displays the most encouraging overall performance in China. The estimates of SM in the northwest of China among all products generally perform poorly on capturing in-situ SM variability due to less coverage of observations. CLSM and ERA5 have a satisfactory correlation coefficient with the observed SM ($R > 0.7$) in the northeast and south of China, respectively. ESA CCI ACTIVE performs with the optimal mean Equitable Threat Score (ETS) value, which indicates the promising ability to drought assessment, followed by CFSR/CFSV2 and ERA5. Specifically, ESA CCI ACTIVE expresses higher ETS in the Yellow River Basin, while CFSR/CFSV2 and ERA5 are more applicable in most areas of the eastern China. This study provides a reasonable reference for the application of SM products in China.